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FINAL REPORT

OF

MAGSAT Correlations with Geoid Anomalies

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MAGSAT Correlations with Geoid Anomalies

A digital data library of MAGSAT data has been created under our prior MAGSAT investigator grant. This library consists of 1,615,636 measurements from the quiet data set, is geographically sorted, and allows rapid analysis and processing of all the quiet magnetic data about any selected location. By using objective Mapping Techniques (Bretherton, et al., 1976; Gandin, 1965) we are able to interpolate the data to profiles composed of equally spaced data points for convenient analysis using time-series techniques in the spatial or frequency domain, or to prepare grids of data points for two-dimensional spatial and frequency analysis and to prepare contour maps. This library of MAGSAT data is compatible with our existing gravity and geoid data library processing and display system software, and thus permits rapid retrieval, processing, filtering, interpolation, and display of MAGSAT data. With this system it is possible to obtain MAGSAT, surface gravity, GEOS-3 radar altimeter geoid, and bathymetric data all at coincident locations. Thus correlations between these data sets now can be conveniently detected and analyzed.

We experimented with the use of removing polynomial trends from each half-orbit as an effective way of estimating and removing ring current effects following estimation of the core field contribution (Langel et al., 1981). We used this method in order to avoid the subtraction of the three linear trends found necessary by Langel et al., (1982) after modeling the ring current

effects by fitting a theoretical mathematical expression for the ring current and, particularly, to avoid the transition problem between one linear trend and the next.

We have examined several sets of coincident orbits where the ground track is nearly identical. In these cases the crust and upper mantle magnetic anomalies should be the same, but different ring current contributions would be expected because the orbits occur at different times, several weeks to months apart. Figures 1 and 2 show the results for two different sets. In Figure 1, the polynomial order curves are purposely displaced vertically from each other for clearer comparison. The polynomial fitting is based only upon the data between 50°N and 50°S latitudes. The best-fitting computed polynomial trends are then subtracted from the entire half-orbit to obtain the anomaly estimates. The higher the order of polynomial fit, generally the smaller are the magnitudes of the estimated anomalies. Our initial studies suggest that a third order polynomial provides the best anomaly estimate. The second order polynomial fit provides good consistency the region of fitting, between 50 degrees north and south latitudes, however, the third degree provides a slightly better degree of consistency both within that same region as well as farther north and south beyond those bounds. Note how well the residuals from the third order polynomial agree with each other in both figures even though the original curves show considerable departures from each other presumably due to time-varying ring current effects. Thus a third order polynomial is the lowest polynomial order that appears to provide the best consistency of residual anomalies between coincident orbits. Because some half-revs yield residual crustal and upper mantle anomalies discordant with data from other nearby orbits, we, like Langel et al., 1982, delete values more than two standard deviations from the mean when interpolating data about a point.

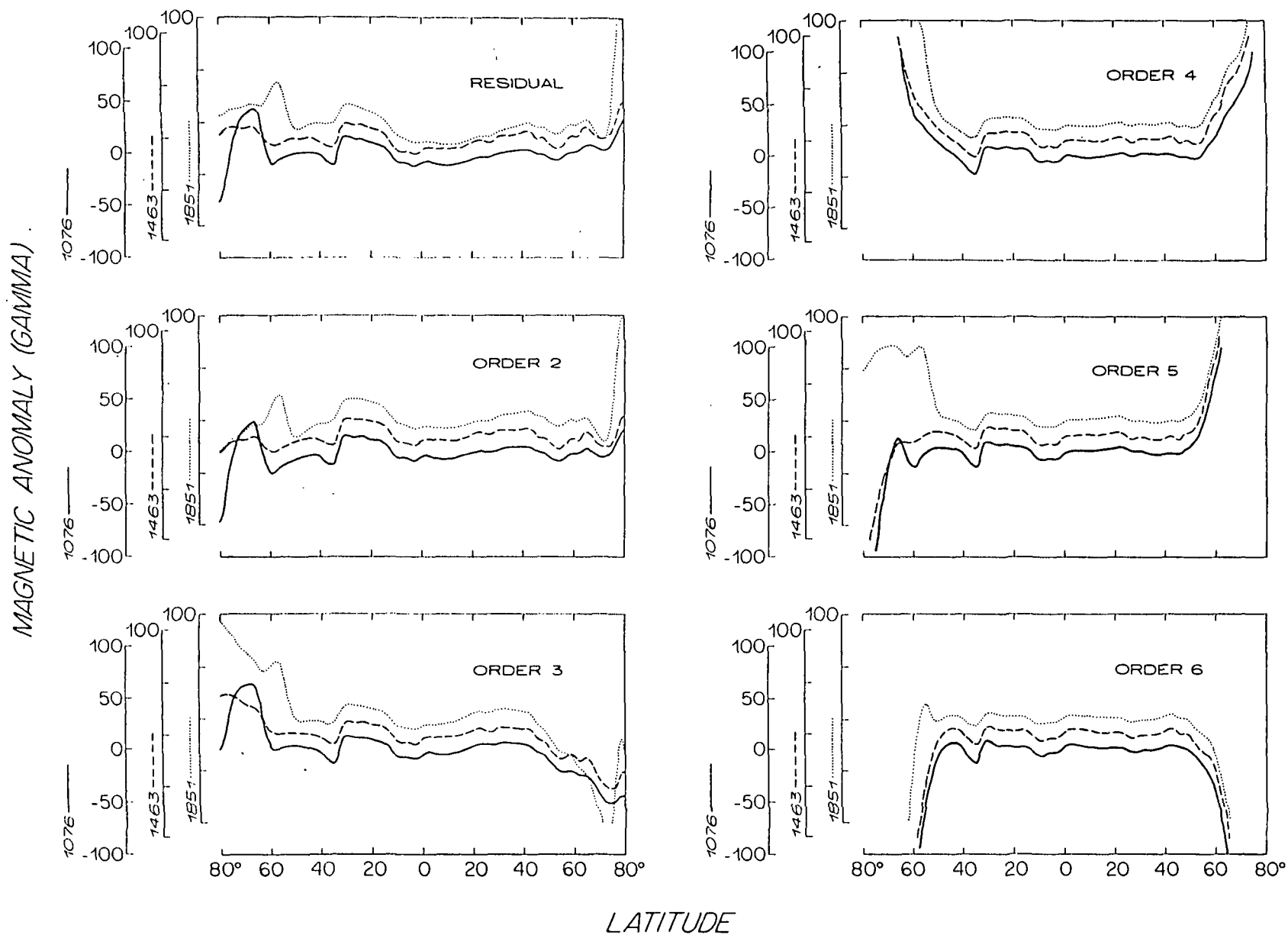


Figure 1. Comparison of data from three coincident MAGSAT orbits. In the upper left hand corner are shown the MAGSAT residual anomaly profiles after removal of a core field represented by spherical harmonic coefficients through degree and order 13 (Langel et al., 1981) for half-orbits 1076, 1463, and 1851. The remaining panels show the residual anomalies remaining after subtraction from the aforementioned residuals of a polynomial trend of the degree indicated. The polynomial trends were computed only from data between 50°N and 50°S, although the continuation of those trends to higher latitudes enable residuals to be calculated over the range 80°N to 80°S.

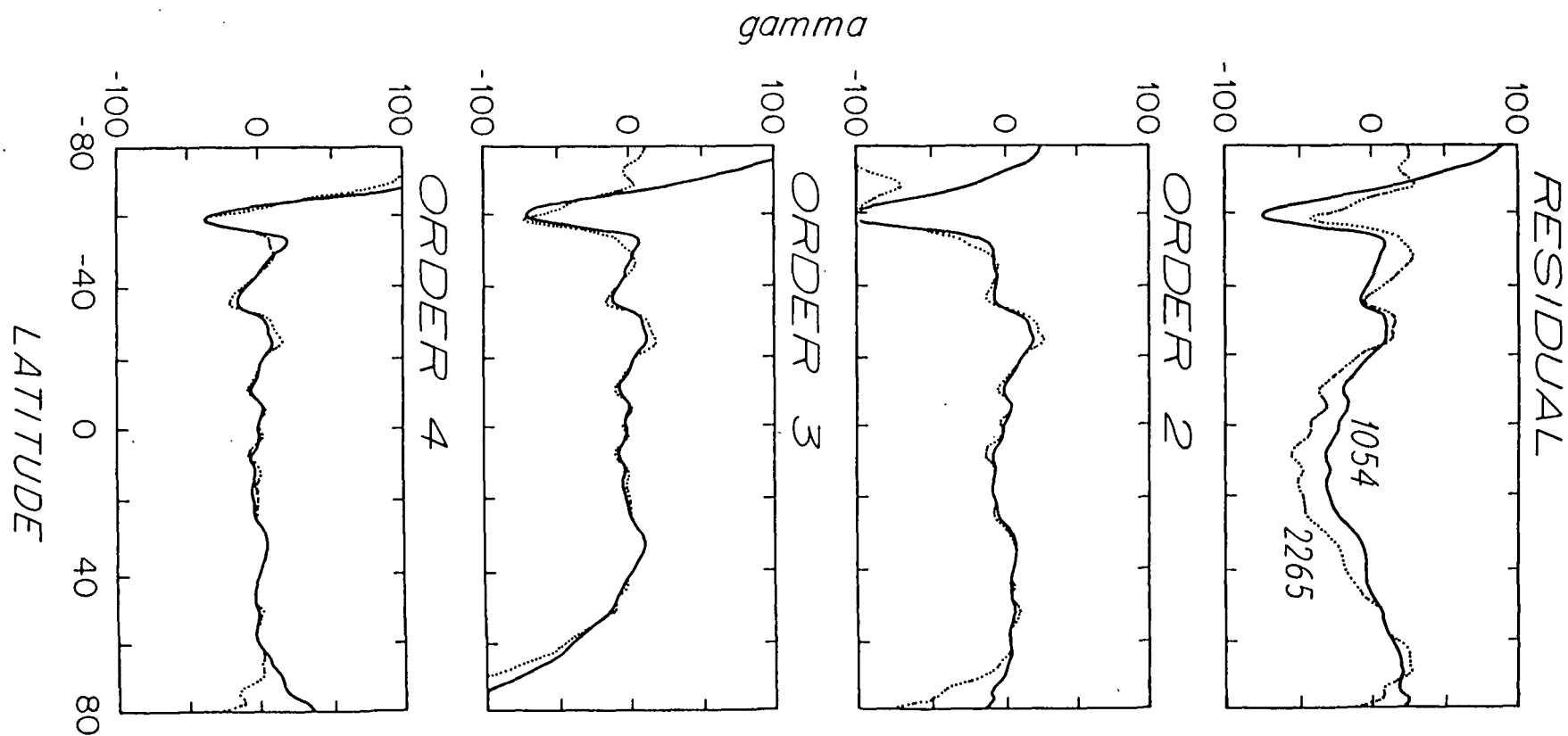


Figure 2. Comparison of data from two coincident MAGSAT orbits. The residuals after removal of core field effects for half-orbits 1054 and 2265 exhibit considerable departures from each other, particularly in the mid-latitudes. These departures are presumably owing to different ring current effects at the different times for the orbit passes. See caption for Figure 1 for explanation of the profiles.

The estimates of crustal and upper mantle magnetic anomalies above 50°N and below 50°S show considerable variation between coincident orbits, and among the residuals using different orders of polynomial fitting. Thus, for the immediate future we plan to concentrate our efforts on the region between those two latitudes. However, we have retained all values in our digital data library because with further examination, selection criteria for identifying valid crustal anomalies may be developed.

Under this NASA support we analyzed the MAGSAT data in the Gulf of Mexico region to define better the possible relation of the negative MAGSAT anomaly there to the negative residual geoid anomaly in the western Gulf of Mexico. The MAGSAT anomaly is seen in the map of Langel, et al. (1982) to lie in the western half part of the Gulf, as does the residual geoid anomaly (Bowin, 1983, Fig. 11). A residual geoid anomaly map of the Gulf of Mexico from a grid having approximately 25 data points per degree square is shown in Figure 3. This is a black and white reproduction of the original in color. The negative residual geoid low is centered at about 25°30'N, 94°45' W.

The locations of MAGSAT measurements in our digital library for the Gulf of Mexico region is displayed in Figure 4. The values at each location along each rev were obtained in the manner previously described. Unfortunately, bias differences, albeit at a lower magnitude than in the original rev data, still remain in the results. For example, in Figure 5 we show the ground tracks for two sets of near adjacent revs for comparisons. Profiles of the western set of revs are shown in Figure 6, and are given in Figure 7 for the eastern set of orbits. Note the general similarity in the shapes of adjacent profiles, although in a few cases, such as for rev 1171 in Fig. 7, the peak to trough relief appears attenuated in comparison with the other profiles. Although the shapes are very similar, superimposing one profile upon others, differences in magnitude of up to

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## Residual Geoid

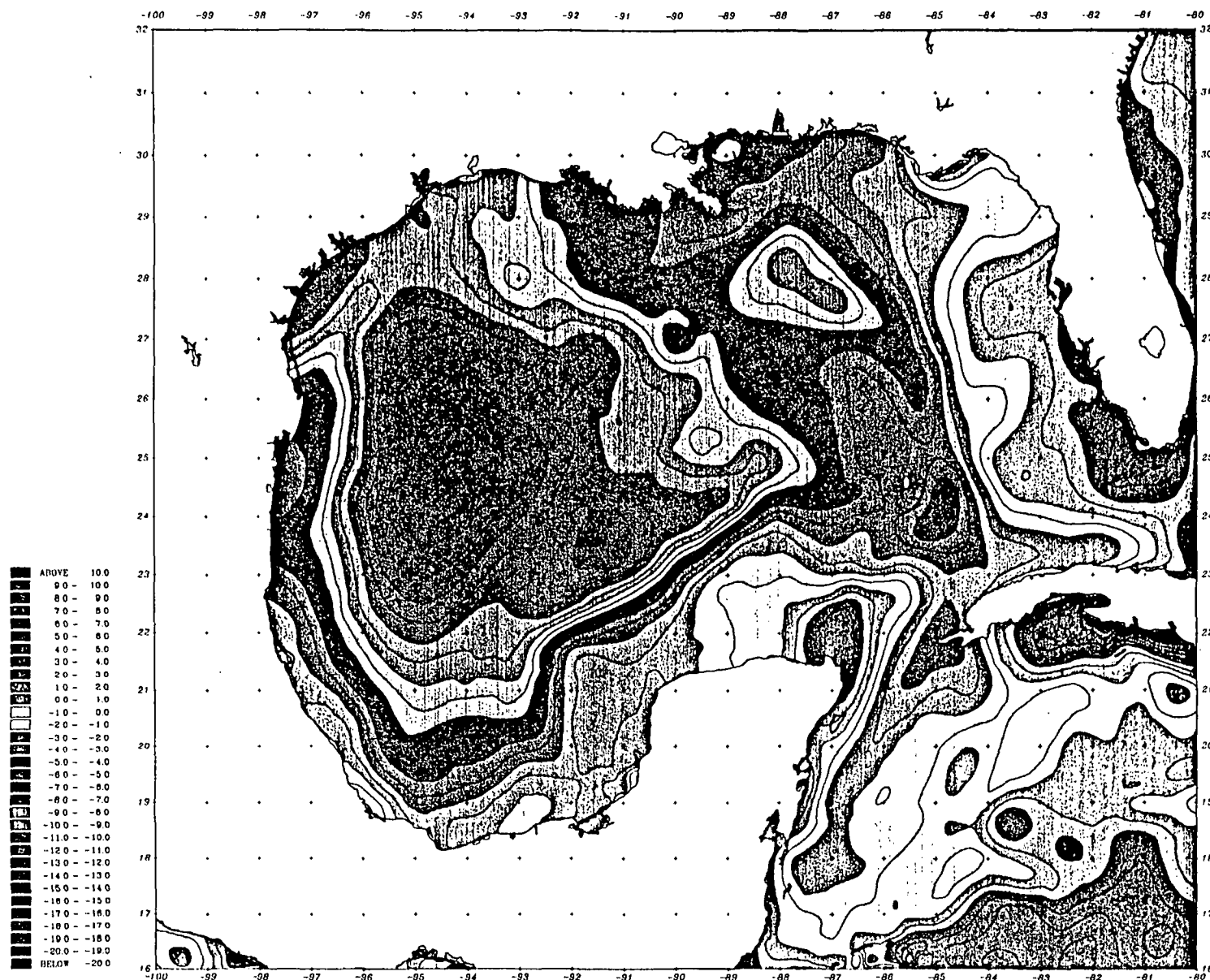


Figure 3. Residual geoid anomaly map for Gulf of Mexico region. Contour interval is 1 m. Obtained by subtracting spherical harmonic GE/9 degree 10 geoid field from the surface geoid field defined by GEOS-3 radar altimeter measurements.

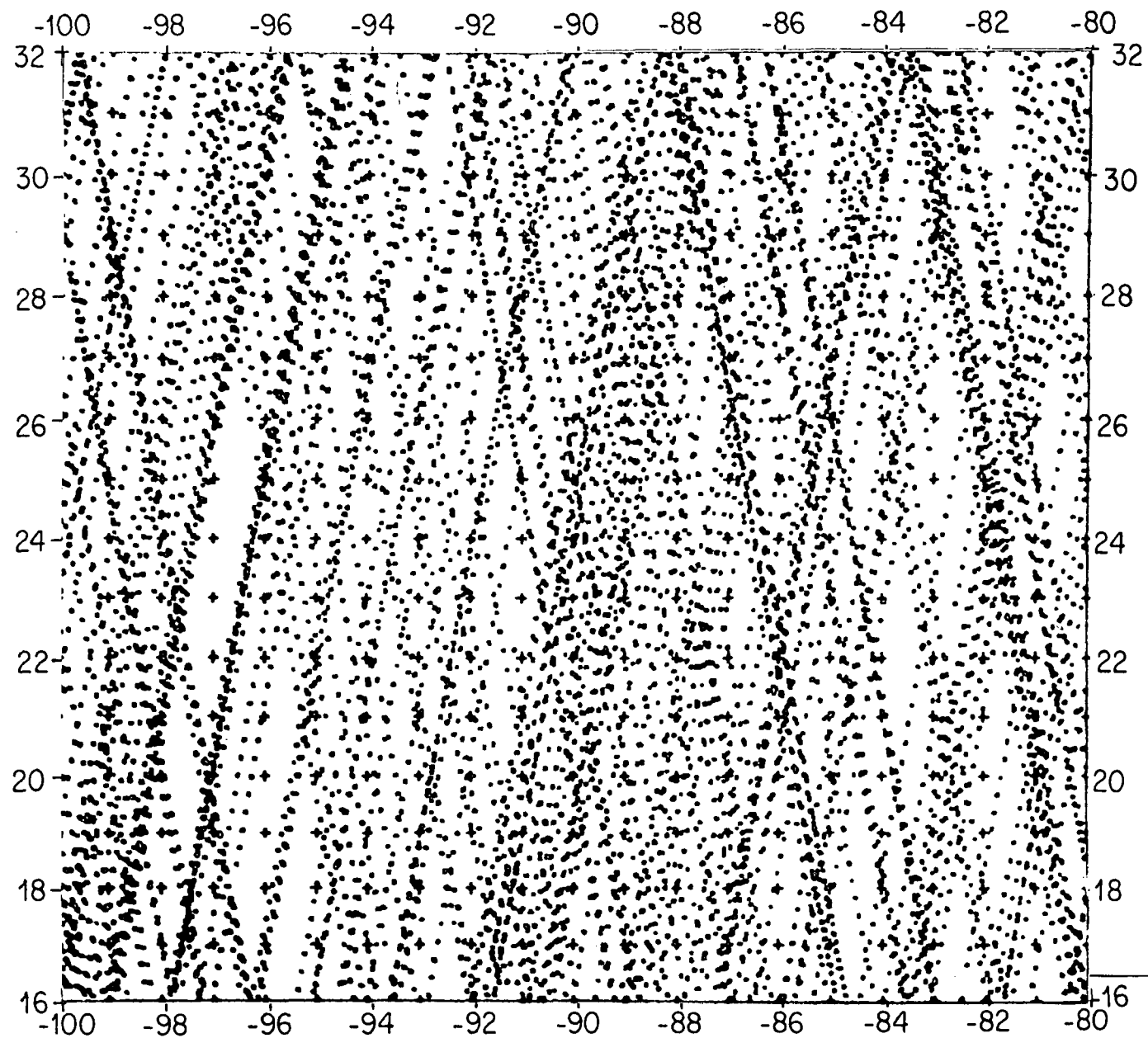


Figure 4. Distribution of MAGSAT magnetic anomaly data in the Gulf of Mexico region.



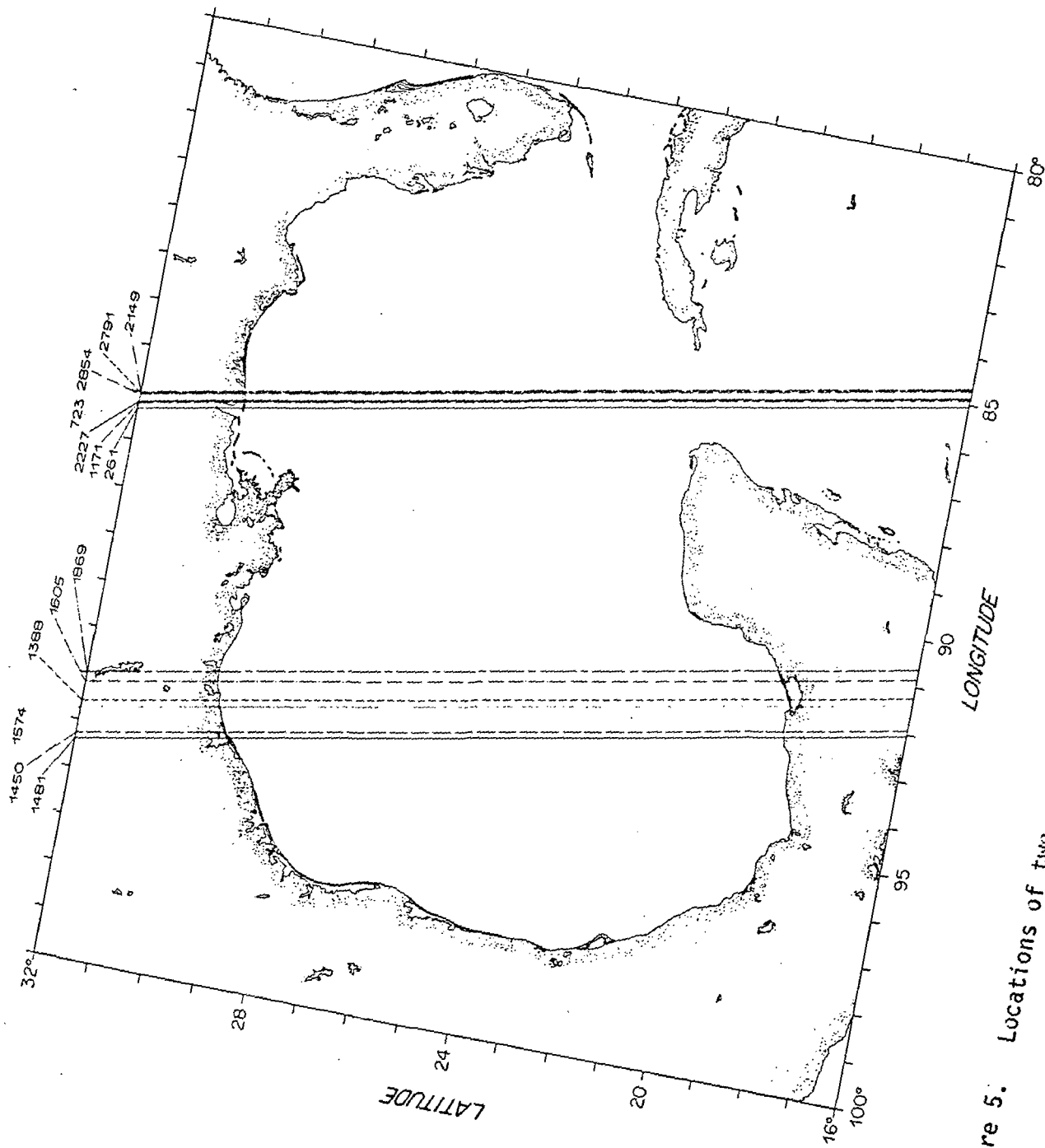


Figure 5: Locations of two sets of nearby MAGSAT revs in Gulf of Mexico

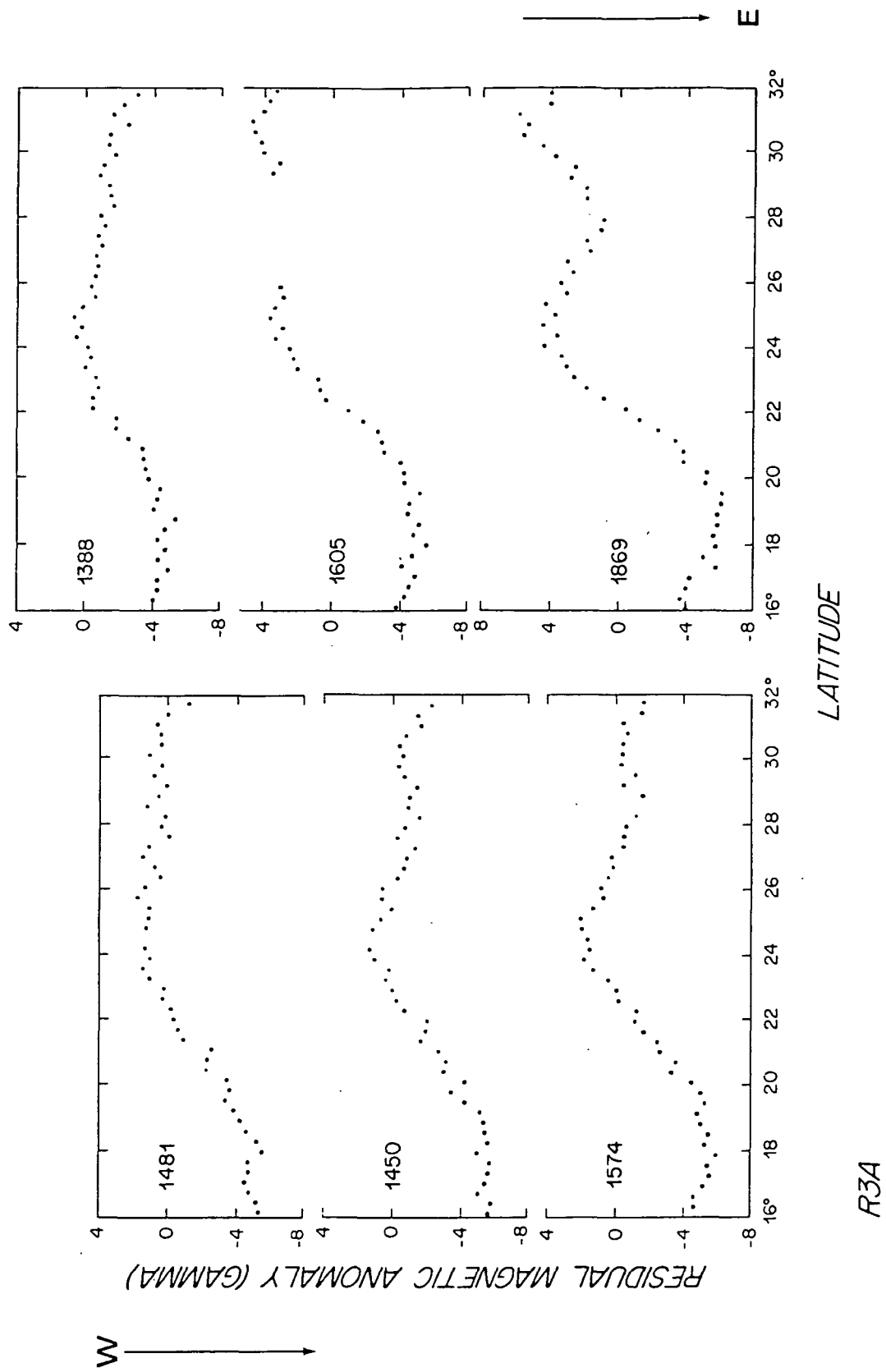


Figure 6. Comparison of data from the western set of adjacent revs in Gulf of Mexico. Location of data shown in Figure 5.

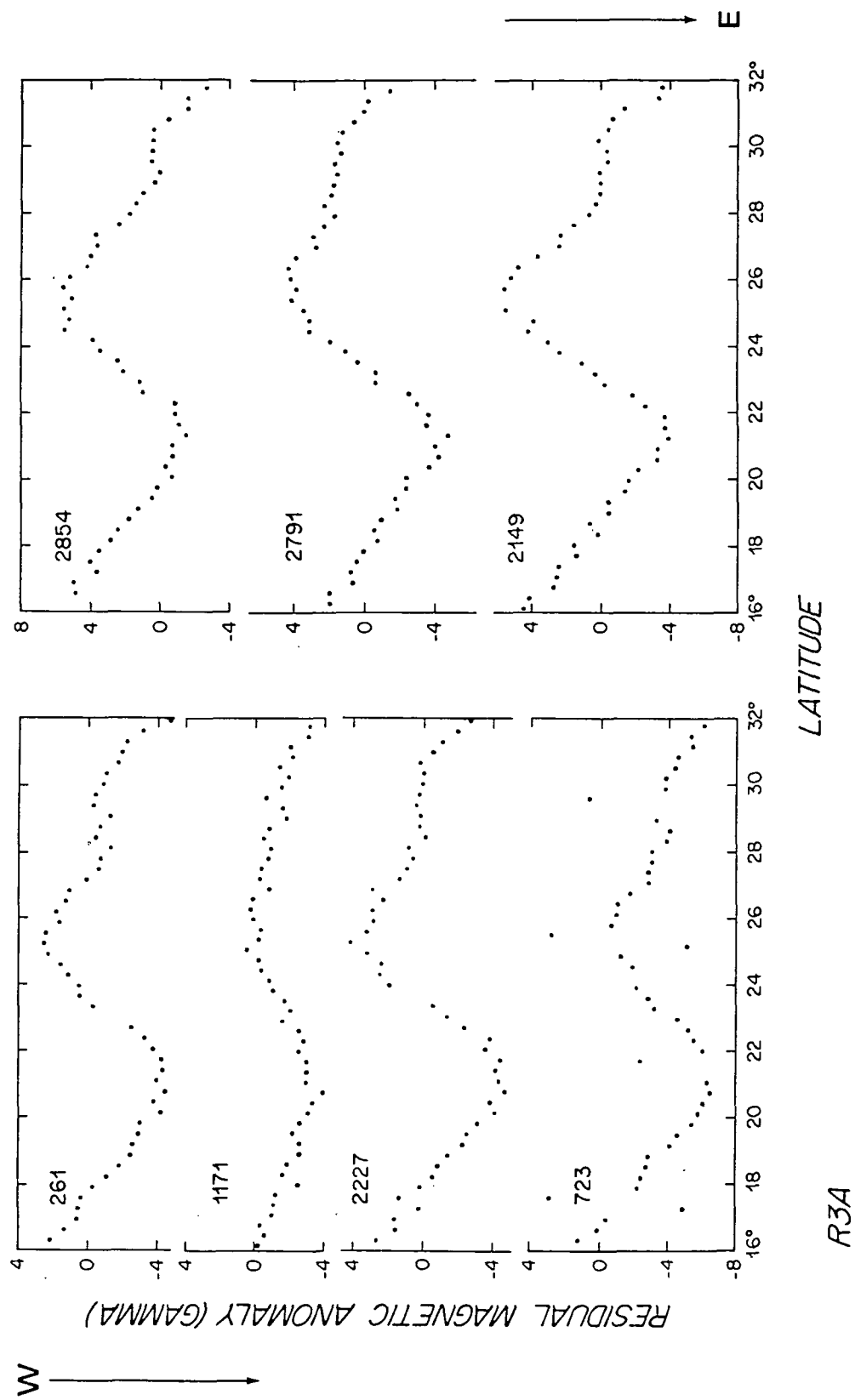


Figure 7. Comparison of data from the eastern set of adjacent revs in Gulf of Mexico. Location of data shown in Figure 5.

four or more gammas can be observed. These differences are not simple bias level shifts since the magnitude of the differences change along the revs. These remaining offsets to about 4 gammas between revs frustrate the direct contouring of the data values at a 1 gamma contour interval. We therefore explored for a way to adjust the data for these data offsets, thereby permitting further analysis.

In Figure 4 note that the MAGSAT data comprise two sets of measurements. Those from the first half of each orbit (starting at the south pole) are ascending revs, have a track azimuth in the Gulf of Mexico region of 170 degrees, and we designate them the A set. Those from the second half of each orbit are descending revs, have track azimuths of about 10 degrees in the Gulf of Mexico, and are referred to as the B set. Polynomial surfaces fit separately to these two sets show striking differences. Compare the individual plots between sets A and B in Figures 8. Note particularly the great difference in the second order two-dimensional polynomial surfaces between sets A and B. We judged the greatest similarity at the lowest order to occur at the third order surfaces. Thus, for the remainder of our experiments we fit a third order polynomial to the combined A and B data sets. This third order polynomial surface was added back at the end of the processing, and served to provide a reference surface to which the rev data could be adjusted rev by rev.

The difference between each rev (half orbit) and the above described 2-D third order polynomial surface was then determined (we call this difference the delta value), and a second order 1-D polynomial curve was fit to each rev profile of delta values. The second order 1-D field was then used to estimate the remaining ring current and estimated core field errors not accounted for in the earlier processing. Hence, a new edited MAGSAT anomaly was calculated by subtracting (on a rev by rev basis) the 1-D polynomial value from the digital

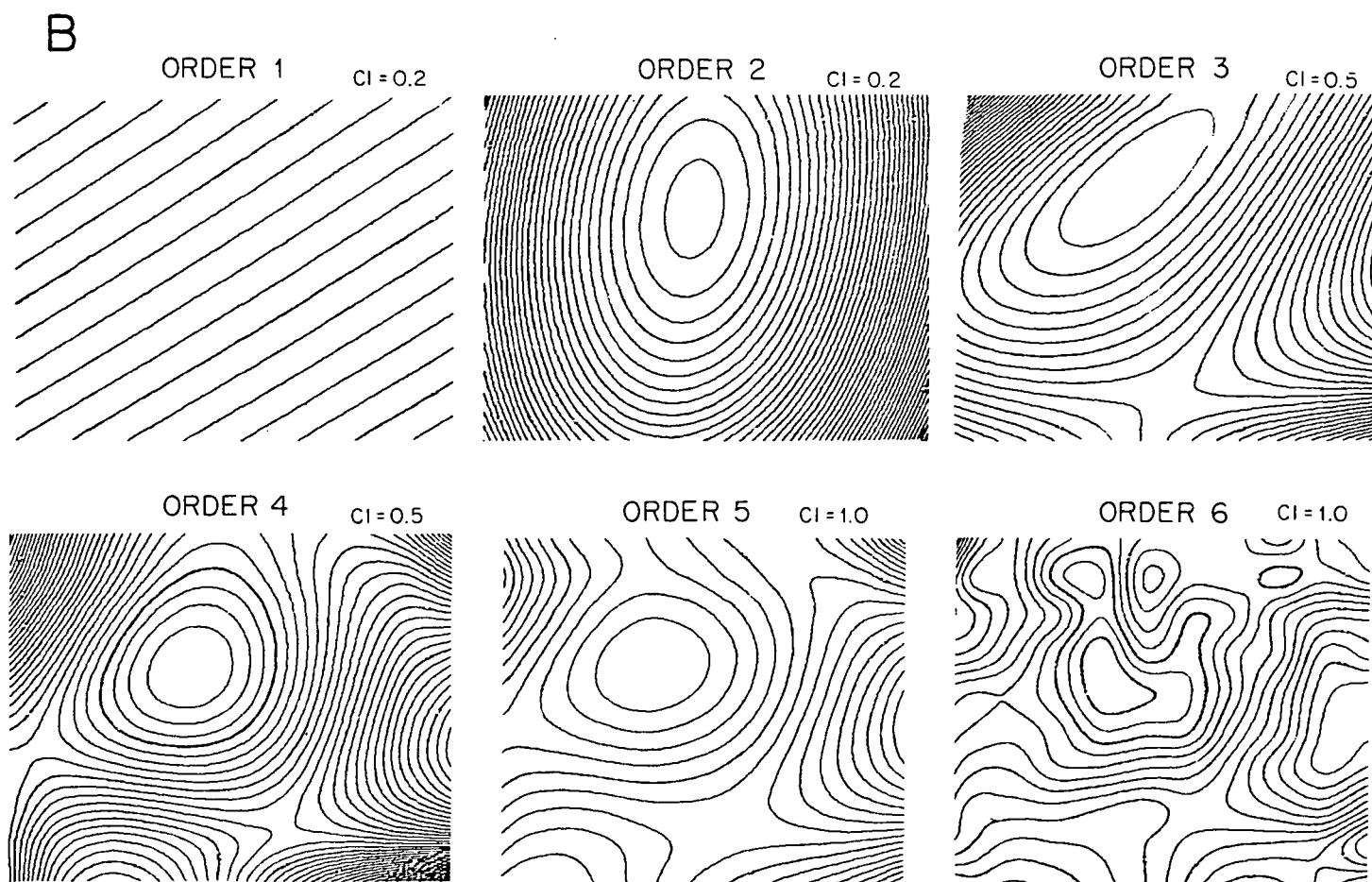
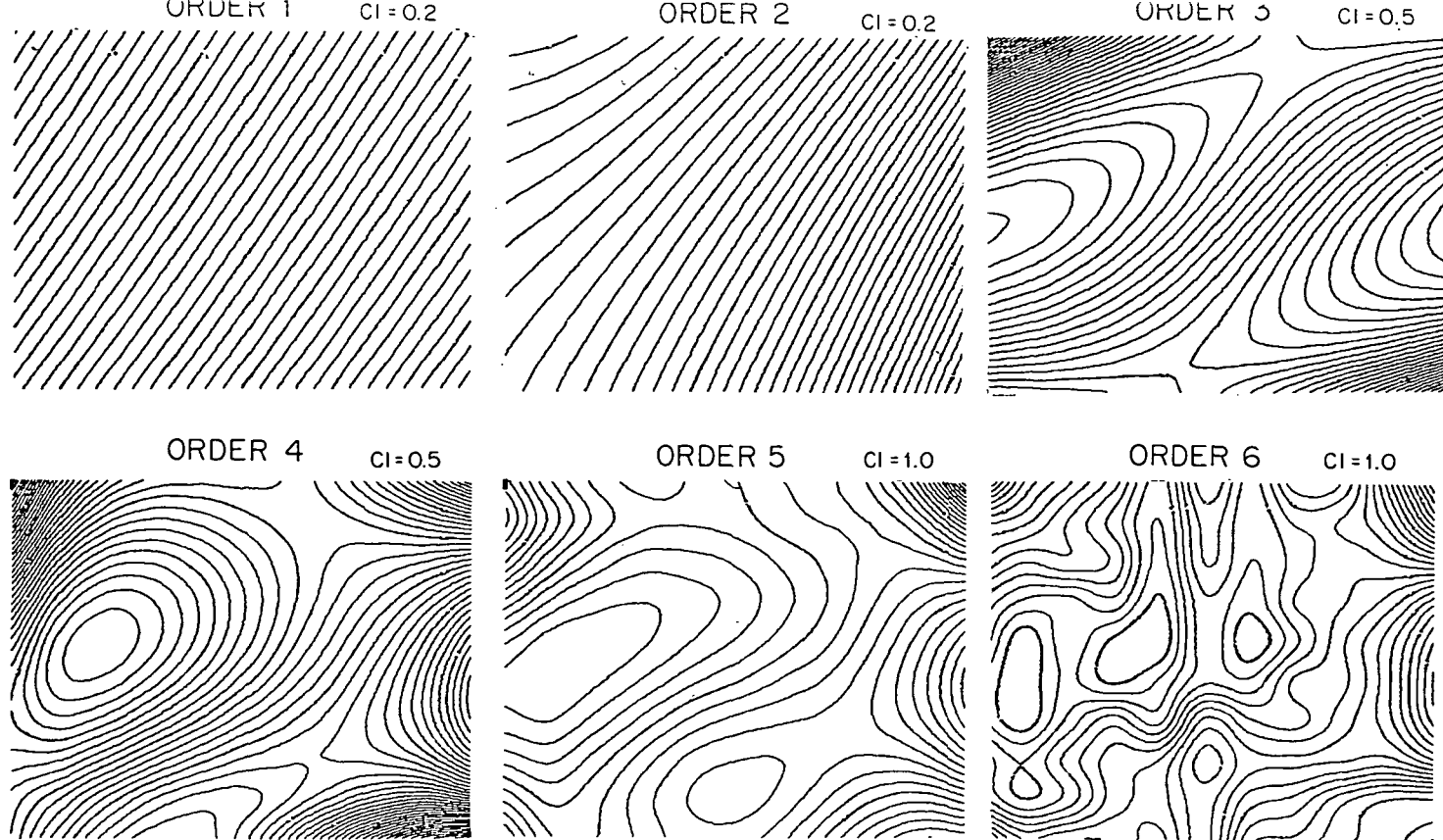


Figure 8. Polynomial surfaces of various orders fit independently to data sets A and B. See text for discussion. The contour interval (CI) in gammas is identified on each plot.

library value, and then adding back the 2-D polynomial reference surface value. The correction then being the discarded second order 1-D polynomial fit to the delta values. The results of these procedures in the Gulf of Mexico region are shown in Figure 9. Upon reaching this stage our NASA and supplemental ONR funds were exhausted and further effort had to be suspended.

The estimated magnetic crustal anomaly pattern seen in Fig. 9 has a magnetic low in the region of the residual geoid low (Fig. 3), but the shape of the anomalies are different. Since the shape and location of the negative magnetic anomaly is variable depending upon the particular polynomial surface and curve orders used, we are reluctant at this time to reach a conclusion either way on the degree of correspondance between the residual geoid and MAGSAT lithosphere anomalies in the western Gulf of Mexico. However, the similarity is suggestive enough to indicate that further attempts at obtaining useful detailed MAGSAT anomaly definition should be continued. Such a capability, of course, would be important and useful for investigations of many features on the earth.

# GULF OF MEXICO

## MAGSAT Crustal Anomaly

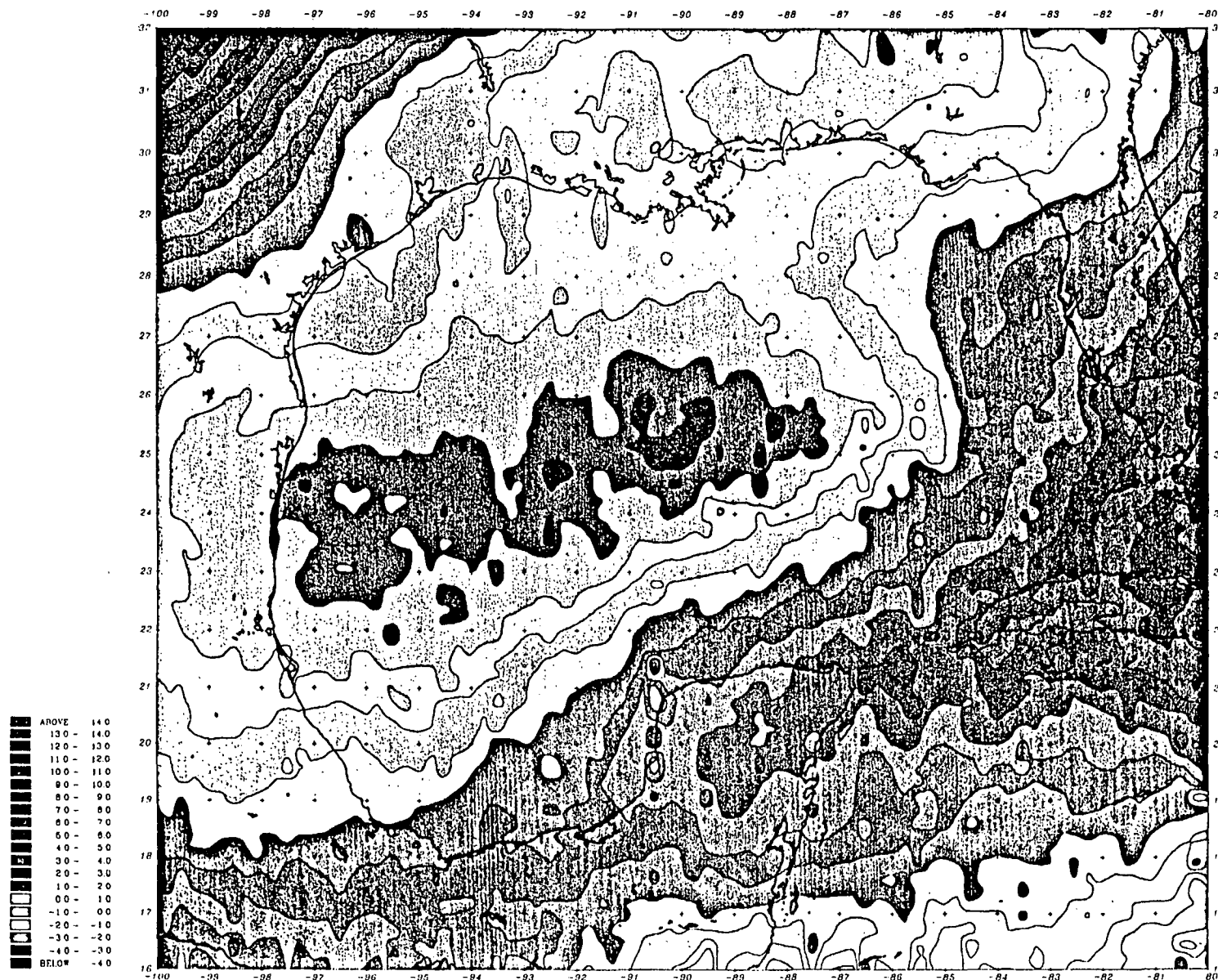


Figure 9. MAGSAT crustal anomaly in the Gulf of Mexico region. Contour interval is 1 gamma. See text for discussion of methodology.

#### REFERENCES CITED

- Bowin, C., 1983, Depth of principal mass anomalies contributing to the Earth's geoidal undulations and gravity anomalies, *Marine Geodesy*, 7, No. 1-4, 61-100.
- Bretherton, Francis P., Russ E. Davis and C.B. Fandry, 1976, A technique for objective analysis and design of oceanographic experiments applied to MODE-73, *Deep Sea Research*, 23, 559-582.
- Gandin, L.S., 1965, Objective analysis of meteorological fields, Israel Program for Scientific Translations.
- Langel, R., J. Berbert, T. Jennings, and R. J. Horner, 1981, MAGSAT data processing: An interim report for investigators, NASA TM 82160.
- Langel, R.A., J.D. Phillips and R.J. Horner, 1982, Initial scalar magnetic anomaly map from MAGSAT, *Geophys. Res. Lettrs.*, 9, 269-272.